Docket No. 2003-053-TAP

METHOD FOR INTELLIGENT TAPE DRIVE SUBSYSTEM CONTROL AND MONITORING IN A TAPE LIBRARY

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to an improved library storage system. More particularly, the present invention relates to a system for adding intelligence to the tape drive tray subassembly in order to provide better control, monitoring, and diagnostics of a library's subsystems.

2. Background of the Invention:

Existing automated storage libraries are capable of storing and retrieving large quantities of information stored on media cartridges. This capability is accomplished by the use of a large number of drive trays, each of which houses a tape drive, that are installed within a library frame. Electrical connections cabled between the tape drive trays and the main library controller or processor provide the main library controller with the means to control and monitor tape drive tray functions.

Designing the interface to monitor and control the tape drive tray subassembly can be a complex endeavor in systems having large enterprise libraries. Currently, customer demands for high availability in the enterprise tape library market require more monitoring of the library's subsystems. As the enterprise market targets

larger and larger libraries, designing the electrical and mechanical infrastructure needed to control and monitor these subsystems becomes a challenging issue.

A conventional tape drive array includes a number of tape drive trays installed in a tape library frame. **Figure 1** depicts an example of a large-scale tape library system which supports 64 tape drive trays. Tape drive trays **102** are grouped into tape drive arrays **104**. Each tape drive tray **102** is connected to the main library controller **106**. Each connection line **108** as shown in **Figure 1** represents multiple signals. Electrical connections between main library controller **106** and tape drive trays **102** provide main library controller **106** with the means to control and monitor tape drive tray functions.

In view of current demands for high availability in the enterprise tape market, conventional tape drive systems contain several disadvantages. One such disadvantage is that as the number of supported tape drive trays increases, more of the library's main controller's bandwidth is required to monitor and control the tape drive trays. For example, the library system as shown in **Figure 1** may require that fans, temperature, and power supply status, as well as software controlled power-on, be monitored for each of the 64 tape drive trays.

Another challenge encountered in designing large-scale libraries is that as the number of tape drives increases, the number of signals between the main library controller and the tape drive array becomes extremely

large. This is an important issue for tape subsystems that support a large number of tape drives (e.g., up to 64 tape drives). Since each tape drive tray interface typically contains fifteen signals, almost one thousand signal connections to the main library controller are required if each drive tray signal is connected directly to the main controller. Physically connecting and routing all of these signals are difficult and costly.

Furthermore, current methods for adding features to a conventional drive tray system typically require adding new signals to the drive tray cabling. As a result, it may be difficult to add features to the drive tray at a later point in time. For systems designed for high availability, adding new signals to the drive tray cabling is problematic because the library must be shut down to make the necessary changes.

Consequently, it would be advantageous to have a system for providing local control and monitoring of a tape drive's subsystems in order to overcome the electrical and mechanical issues encountered in high availability enterprise libraries in the prior art. It would further be advantageous to have a system that provides flexibility for the addition of future features.

SUMMARY OF THE INVENTION

The present invention provides a system for adding intelligence to the tape drive subsystems of a media storage library. The capabilities added to the tape drive subsystems improve overall system availability by enhancing existing control, monitoring, and diagnostic functionalities. As a result of inserting an intelligence module into the drive trays, certain control and monitoring functions traditionally performed by the main library controller may be performed locally at the drive trays. For example, the tape drive tray may monitor the environmental status (e.g. fan speed, temperature, etc.), of the library subsystems.

The present invention also provides flexibility to the storage system, for as tape drive technology changes, new features and functions may be added to the drive tray subsystem without the need to modify the base library cabling infrastructure. This flexibility is desirable in order to protect the customer from library obsolescence.

Furthermore, the present invention may be used to improve tape drive tray diagnostics. Adding intelligence to the drive tray provides for diagnostic features such as, for example, fan speed control, fan operation monitoring, temperature measurement, power supply monitoring, cable integrity validation, fault reporting, to be performed locally at the drive tray.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

Figure 1 depicts a known tape drive array;

Figure 2 is a perspective view of a tape drive tray assembly consistent with implementing a preferred embodiment of the present invention;

Figure 3 depicts a block diagram of the drive tray electronics in accordance with a preferred embodiment of the present invention;

Figure 4 is a flowchart illustrating an exemplary method of employing intelligence added to the drive trays in accordance with a preferred embodiment of the present invention; and

Figure 5 is a flowchart illustrating an alternative method of employing intelligence added to the drive trays in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention solves the problems present in the prior art by adding intelligence to the tape drive subsystems. Local intelligence is implemented in the tape drive trays to allow the drive trays to control and monitor particular functions within the library subsystems. Possible functions provided by the drive tray include monitoring the tape drive power supply and controlling the tape drive power on/off setting, monitoring the temperature, monitoring and controlling the air flow by managing the fan speed, and service features. In the preferred embodiment, the present invention is implemented in a drive tray subsystem within a single library storage frame.

Figure 2 is a perspective view of a tape drive tray assembly consistent with implementing a preferred embodiment of the present invention. Tape drive tray **200** is a library subsystem comprising a tape drive **202** mounted in frame **204**. Other items may also be included within tape drive tray assembly **200**, such as a power supply, fan assembly, indicator lights, and temperature sensor. Frame **204** may be any general support structure for mounting the components of the tape drive in an operative relationship. Tape drive tray controller electronics **208** are mounted into frame **204** to provide intelligence to tape drive tray **200**. Tape cartridge **206** may be automatically drawn into tape drive **202** when inserted, and removed by sending an eject command over the tape drive's library interface.

As stated previously, the present invention adds intelligence to the tape drive subsystems. An advantage of adding electronics to the drive trays to locally perform particular functions normally reserved for the library's main controller is that the library's main controller will subsequently require less bandwidth for these functions. This bandwidth requirement is an important issue for tape subsystems that support a large number of tape drives. The capabilities added to the drive tray help to provide better control, monitoring, and diagnostics, thus improving overall system availability.

In addition, a serial link may be used to communicate between the drive trays and the main library controller. Passing data serially rather than using separate wires for each function minimizes the number of required signal lines. An additional benefit to using a serial link is that new features can be added to the drive tray without additional cabling to the main library controller.

The present invention provides another advantage over the prior art for as the library's main controller requires less bandwidth to perform certain functions, fewer connections are required between the drive tray and the main library controller. Consequently, even if the size of the tape drive array increases, the performance of the main library controller will not be degraded.

Referring now to **Figure 3**, a block diagram of the drive tray electronics for a single drive tray in accordance with a preferred embodiment of the present

invention is shown. This single drive tray illustrated in **Figure 3** may be, for example, one of the drive trays shown in drive tray array **104** in **Figure 1**.

The tape drive subassembly is commonly referred to as a drive tray. Drive tray **302** contains various items, such as, for example, a tape drive **304**, power supply **306**, fan **308**, temperature sensor **310**, and indicator lights for power and fault status **312**. Tray controller electronics **314** are inserted into the drive tray **302**. Tray controller electronics **314** periodically samples status signals generated from devices within drive tray **302**. Such signals may include tape drive power okay **316**, fan status **318**, and temperature data **320**. Tray controller electronics **314** sends the status signals to main library controller **322** through tray controller interface **326**. The status signals may be sent in a serial format.

Main library controller **322** may also transmit control information through tray controller interface **326** to tray controller electronics **314**. The control information is transmitted to tray controller electronics **314** in a serial fashion. Tray controller electronics **314** decodes the serial data and then drives the discrete signals of the specific interface being addressed. For example, if the transmitted data includes control information such as tape drive power on/off, tray controller electronics **314** drives the power supply **306** on/off control input to the state specified in the command. Likewise, if the transmitted data includes control information such as fan speed, tray controller

electronics **314** drives the fan speed input of the fan **308** to the state specified in the command.

It should be noted that two separate serial interfaces are shown in **Figure 3**, one for the tape drive's library interface **324** and another for the tray controller electronics **326**. It should be noted that it is possible to combine the two interfaces into a single one to further reduce cabling. A further improvement would be to utilize wireless communications means such as radio frequency (RF) or infrared (IR). In addition, one of ordinary skill in the art would understand that the serial interface used for tray controller electronics interface **326** may include any type of serial interface, such as, for example, RS-232, RS-422, RS-485, Ethernet, USB, P1394 (FireWire), or Fibre Channel. Furthermore, various transmission mediums such as, for example, wired channels (cable), optical fiber, and radio frequency (RF) may be used to transfer information through tray controller electronics interface **326**. One of ordinary skill in the art would understand that the present invention includes, but is not limited to, the interface types and transmission mediums listed above.

Figure 3 illustrates how adding intelligence to the drive tray can also be used to improve tape drive tray diagnostics. For example, implementing a loopback mode **328** for the tape drive's library interface port allows the main controller to verify cable integrity. During normal operation, the tray controller electronics **314** transparently passes library interface data between tape drive **304** and main library controller **322**. In response

to main library controller **322** sending a command to tray controller **314**, the library interface port may be placed in loopback mode **328**. Data transmitted to drive tray **302** by main library controller **314** is routed or "looped back" to main library controller **314** receive data. Consequently, main library controller **314** is able to verify the integrity of the signal lines to drive tray **302**.

Turning now to **Figure 4**, a flowchart illustrating an exemplary method of employing the intelligence added to the drive trays in accordance with a preferred embodiment of the present invention is shown. Once electronics are added to the drive trays, drive tray electronics periodically sample status signals generated from devices within drive tray (step **402**). Such signals may include tape drive power okay, fan status, and temperature data. The tape drive tray electronics sends the status information to main library controller in a serial format (step **406**).

Figure 5 is a flowchart illustrating an alternative method of employing the intelligence added to the drive trays in accordance with a preferred embodiment of the present invention. The main library controller may send control information to the drive tray electronics. The process begins with the main library controller transmitting a command to the tape drive tray in a serial manner (step **502**). Upon receipt of the command, drive tray electronics decodes the serial data (step **504**), and drives discrete signal lines to their states as specified in the command (step **506**). For example, if the

transmitted data includes control information such as tape drive power on/off, the drive tray electronics drives the on/off input of the power supply to the on or off state specified in the command. Likewise, if the transmitted data includes control information such as fan speed, the drive tray electronics drives the fan speed input to the state specified in the command.

Thus, the present invention provides a system for adding intelligence into tape drive subsystems. The advantages of the present invention should be apparent in view of the detailed description provided above. The capabilities added to the drive tray help to provide better control, monitoring, and diagnostics, thus improving overall system availability. As a result of adding drive tray electronics, fewer connections are required between the tape drive and the main library controller. In addition, the main library controller's performance is not degraded as the number of tape drives increases.

The present invention also provides flexibility to the storage system, for as tape drive technology changes, new features and functions may be added to the drive tray subsystem without the need to modify the base library cabling infrastructure. This flexibility is desirable in order to protect the customer from library obsolescence. Furthermore, the present invention may be used to improve tape drive tray diagnostics. Adding intelligence to the drive tray provides for diagnostic features such as fan speed control, fan operation monitoring, temperature measurement, power supply monitoring, cable integrity

validation, fault reporting, to be performed locally at the drive tray.

The description of the present invention has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. For example, although the depicted examples employ the use of a power supply, fan, temperature sensor, and fault indicator light, other features may be used depending upon the type of monitoring desired.

Furthermore, use of the present invention may be expanded beyond the applications already listed above. For example, an intelligent tape drive tray controller could be used to monitor the tape drive library interface port and provide diagnostic results to the main library controller. In addition, operation of the tape drive may be monitored. For instance, the health of the tape drive may be checked periodically and necessary updates to the drive code may be provided to the tape drive.

Additionally, the intelligent tape drive tray controller may be used to facilitate library interface and data path protocol conversions, wherein the drive tray controller handles control of the interaction among the functional units. Furthermore, the present invention may be used to electromechanically control various features within the library system, such as controlling the solenoid tray lock, media enter & eject assist, and other features present in the library system.

It is important to note that while the present invention has been described in the context of a fully functioning data processing system, those of ordinary skill in the art will appreciate that the processes of the present invention are capable of being distributed in the form of a computer readable medium of instructions and a variety of forms and that the present invention applies equally regardless of the particular type of signal bearing media actually used to carry out the distribution. Examples of computer readable media include recordable-type media such a floppy disc, a hard disk drive, a RAM, CD-ROMs, and transmission-type media such as digital and analog communications links.

The description of the present invention has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. The embodiment was chosen and described in order to best explain the principles of the invention, the practical application, and to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are suited to the particular use contemplated.